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(54) Wrist-wearable device comprising an antenna

Am Handgelenk tragbare Vorrichtung mit einer Antenne

Dispositif portable à poignée comportant une antenne

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EP 2 178 158 B1

Description

[0001] The present invention is directed to a wrist-wearable device comprising an outer housing with a back cover, a front cover being parallel to said back cover, and a circumferential wall there between, said wall being substantially perpendicular to the back cover and to the front cover. The wrist-wearable device can for example be a wrist-top computer or a watch. The device further comprises at least one antenna which is able to send and to receive electromagnetic signals.

[0002] There exist various watches and wrist-top computers comprising an antenna for wireless data transfer into and out of the device.

[0003] The UK patent application published as GB 2431522 A for example discloses a wrist-wearable device having an outer housing with a slot being formed in the housing to provide a slot antenna. The longitudinal direction of the slot is parallel to a dial portion of the wrist-wearable device and is used for wireless communication with a communication network.

[0004] Various portable radar speedometers are also known from prior art. Radar speedometers normally comprise a radar transmitter associated to a first antenna and a radar receiver associated to a second antenna. Often, patch antennas or rod antennas are used for this kind of application. A drawback of these antenna technologies is that they are not well-suited for flush assembly on metallic watch cases. Furthermore, due to capacitive loading, patch antennas gets easily detuned in the proximity of human tissue while rod antennas are apparently very sensitive to their surroundings and would thus be affected by the construction of the interior of a wrist-wearable device if integrated into such a device.

[0005] The present invention aims at integrating a radar speedometer in a wrist-wearable device. In particular, this integration should be possible independently on the material chosen for the outer housing of the wrist-wearable device, i.e. as well for metal housings as for a plastic housing.

[0006] This aim is achieved by a wrist-wearable device according to claim 1 comprising two slot antennas each slot antenna comprises a case having electrically conducting inner surfaces and being fitted in the housing. Said case is limited on one side by an outer face lying substantially in a common plane with the wall of the housing. A slot extending substantially in a direction perpendicular to the back cover and to the front cover is formed in said outer face of the case, the inside of the case thereby forming a cavity of the slot antenna.

[0007] The case of the slot antenna having electrically conducting inner surfaces serves as a cavity for the slot antenna. The invention can be used with a wrist-wearable device having a housing which is made of an electrically conducting material, in particular of metal. In an alternative example not forming part of the invention the device has a plastic housing. A slot antenna is very robust in terms of radiation characteristics against modifications of the interior of the watch case and is thus particularly suitable for radar speedometer applications as mentioned above. Furthermore, one can obtain a very large width of the main beam horizontal pattern.

[0008] Preferred embodiments of the invention arise from the dependent claims and the following description.

[0009] According to the invention, the device comprises two slot antennas, each of them having a case and a slot being formed in the outer face of said case, wherein the circumferential wall comprises an high impedance portion lying between the outer faces of the two cases. An embodiment with two slot antennas is particularly suitable for a radar speedometer application, as one antenna can be associated to a radar transmitter and the other one to a radar receiver. In an example not forming part of the invention, it is also possible to use only one slot antenna. In this case it is necessary to provide additional radio components such as circulators on the transceiver side. Such a solution is slightly more costly than a solution using two antennas, but may be preferable in certain cases for aesthetic and design reasons.

[0010] When two slot antennas are employed, the high impedance portion lying between the outer faces of the two cases reduces surface coupling between the two slots.

[0011] The slot of the first antenna can be tilted with respect to the slot of the second antenna. Such an arrangement can be chosen for design reasons.

[0012] According to a preferred embodiment, the outer housing is at least partly made of a conducting material, in particular of metal, and the case of the slot antenna is electrically insulated from said outer housing. The capacitive coupling between the watch case and the antenna or antennas which would normally occur with a metal housing can thereby be considerably reduced.

[0013] According to an alternative example not forming part of the invention, the outer housing is substantially made of a non-conducting material. For example, the circumferential wall and the back cover can be made of a plastic material, while the front cover can either be made of glass or of a plastic material having a transparent portion.

[0014] When such a plastic housing is used, the device may advantageously comprise at least one electrically conducting surface on the circumferential wall. This electrically conducting surface will form a continuous antenna surface together with an adjacent outer surface of the case of the slot antenna. Such a bigger antenna surface can help to improve the radiation pattern.

[0015] According to a preferred embodiment of the invention, the device further comprises a shielding element lying in the plane of the back cover and protruding from the wall in an area below the slot antenna. When two slot antennas are provided, a common shielding element may be provided in an area below the two slot antennas, or two separate shielding elements, one below each slot antenna, may be provided. The shielding tilts the main lobe directivity, and radiation is thus guided away from

the user's wrist.

[0016] Preferably the device further comprises a transmitter generating a radar signal and connected to a first slot antenna as well as a receiver and a signal processing unit connected to said receiver, the receiver being connected to the second slot antenna.

[0017] The signal processing unit can be arranged to compute a speed of a person wearing the wrist-wearable device using signals captured by the second slot antenna. The device may furthermore comprise display means which are arranged to display a speed and/or a covered distance calculated by a signal processing unit.

[0018] The subject matter of the invention will be explained more in detail in the following description with reference to the drawings, wherein:

Fig. 1 is a perspective view of a device according to an example;

Fig. 2 is a cut view along the axis II-II in Fig. 1; and

Fig. 3 is a block diagram of the electronic components of the device shown in Figs 1 and 2.

[0019] It will be appreciated that the following description is intended to refer to one specific embodiment of the invention which has been selected for illustration in the drawings but which is not intended to define or limit the invention, other than in the appended claims.

[0020] Fig. 1 shows a perspective view of a wrist-wearable device, in the present case a wrist watch. The device comprises an outer housing 1 with a back cover 3 and a front cover 4, in the present case a glass for covering a dial with hands 6, 7 and an electronic display 20. A circumferential wall 2 lies between the back cover 3 and the front cover 4 and completes the housing 1. This wall 2 is shown as being substantially perpendicular to the front cover 4 and the back cover 3, but a toroidal or rounded shape or any other shape known in watch design is possible. It should also be noted, that the back cover 3 and the front cover 4 are shown as being circular, but they may also be oval or rectangular with or without rounded edges without departing from the scope of the present invention.

[0021] The device shown in Fig. 1 comprises two slot antennas 8, 9, each of them comprising a block-shaped case 8b, 9b and a slot 8a, 9a. The cases 8b, 9b are either made of metal or of another material having a metallized inner surface and form a cavity for the slot antennas 8, 9. This cavity can be filled with a dielectric material having a high dielectric constant and a low dielectric loss such as Teflon®, a dielectric ceramic material or an appropriate resin. Cavity backed slot antennas are known in the art and their function principle will thus not be discussed here. It should be noted, however, that the minimum slot length which is required depends on the wavelength of the radar signal, the permittivity of the dielectric filling material and the shape of the slot. For the present application it is in general desired to reduce the slot length as much as possible so that the height e (cf. Fig. 1) of the wrist wearable device can be reduced. To do so, the shape of the slot may be adapted. It is possible, for example, to use a slot comprising a vertical main slot as shown in the figures and to provide it with additional slot structures which are perpendicular to this main slot, i.e. parallel to the front cover 4 and back cover 3.

[0022] Both cases 8b, 9b have an outer face 8c, 9c which coincides with the circumferential wall 2 of the housing, the slots 8a, 9a being formed in said outer face, respectively. The outer faces 8c, 9c are metallized or made of metal and form an antenna surface together with adjacent metal plates 8d, 9d, as it will be explained below. In the example shown in Fig. 1, the slots 8a, 9a are both oriented in a direction perpendicular to the back cover 3 and to the front cover 4 and are thus parallel to each other. However, one of the slots 8a, 9a may be slightly tilted with respect to the other slot 9a, 8a, and would in this case not be exactly perpendicular to back cover 3 and front cover 4. It is also possible to tilt the slot with respect to a vertical axis. For example, instead of being exactly perpendicular to the back cover 3 and front cover 4, the slots 8a, 9a could be arranged such that the angle between the front cover 4 and the slots 8a, 9a is smaller than 90°. In this case the radiation is directed away from the user's wrist. As mentioned above, the length of the slot 8a, 9a is determined by different factors, but it will normally be only slightly inferior to the height e of the circumferential wall 2 as shown in Fig. 2.

[0023] In the example shown in Fig. 1, the housing 1 and in particular the wall 2 are made of a plastic material. The two cases 8b, 9b of the slot antennas 8, 9 are not directly adjacent, but are arranged at a certain distance d and are thus electrically insulated from each other. The example is not limited to devices having plastic housings, however, and the housing 1 can be completely made of metal or comprise metallic parts. If according to the invention the circumferential wall 2 is made of an electrically conducting material, a high impedance portion will be provided in the wall 2 between the outer surfaces 8c, 9c. Such a high impedance portion avoids a coupling of the two antennas via surface waves. A simple solution would be a plastic insert or a plastic element applied to the surface of the circumferential wall 2 between the two slot antennas 8, 9. Alternatively, one can also use appropriate geometrical structures formed in the metal wall 2 such as photonic bandgap structures.

[0024] In the example shown in Figs. 1 and 2, two metal plates 8d, 9d are applied to the circumferential wall 2 on the left, respectively on the right, of each of the outer surfaces 8c, 9c of the antennas 8, 9. The electrically conducting surface of these metal plates 8d, 9d forms a continuous antenna surface together with the respective outer surface 8c, 9c of the slot antenna 8, 9, and the radiation pattern is improved thereby. It is obvious that it is not necessary to apply metal plates to the circumferential wall 2 of the housing 1 of the device, if the wall 2 itself is

made of an etectrically conducting material such as stainless steel or another metal according to the invention. In such a case parts of the housing 1, in particular parts of the wall 2, can directly be part of the antenna surface.

[0025] The horizontal radiation pattern is denoted with the reference numerals 10, 11 in Fig. 1. The beam width α of the horizontal pattern (cf. Fig. 1) will be above 150°, preferably around 180° or higher, if the size of the outer surfaces 8c, 9c respectively the size of the metal plates 9c, 9d are chosen appropriately. Appropriate distance between the two slot antennas 8, 9, has to be selected to achieve the required value of antenna decoupling.

[0026] The housing 1 is provided with a shielding element 5 lying in the plane of the back cover 3 and protruding from the wall 2 below the slot antennas 8, 9 and below the segment of wall 2 lying between them. The effects of this shielding become clear when looking at Fig. 2 which shows a cut along the axis II-II in Fig. 1. One sees that the shielding 5 tilts the main beam directivity direction 13 with respect to the plane of the back cover 3, the tilting angle being denoted as γ in Fig. 2. This protects the user from the radiation emitted and received by the device, and an attenuation of the signal in the tissue of the user wearing the device is avoided. The vertical radiation pattern obtained is shown in Fig. 2. and denoted with the reference numeral 12. The beam width β of the vertical pattern 12 can reach up to 90° or more.

[0027] Fig. 3 is a block diagram showing the electronic components necessary for the implementation of a radar speedometer in the device shown in Figs. 1 and 2. A transmission chain 14 associated to a first slot antenna 8 comprises a radar transmitter 17 emitting a radar signal which is amplified by an amplifier 16. The amplified radar signal will be emitted via the slot antenna 8.

[0028] The second slot antenna 9 is part of a reception chain 15 and is connected to a signal processing unit 19 via a receiver 18 and an amplifier 16' amplifying the signal received by the antenna 9. The signal processing unit 19 calculates a speed of the user wearing the device shown in Fig. 1 using an appropriate algorithm. Based on the speed, the signal processing unit may also calculate the distance covered by the user. The speed and/or the distance covered can then be shown by the display 20 which is integrated into the device.

Reference numerals

[0029]

1	housing
2	circumferential wall
3	back cover
4	front cover
5	shielding
6, 7	hands
8, 9	slot antenna
8a, 9a	slot
8b, 9b	case
8c, 9c	outer surface of case
8d, 9d	electrically conducting surface
10, 11	horizontal radiation pattern
12	vertical radiation pattern
13	main beam directivity direction
14	radar emission unit
15	radar reception unit
16, 16'	amplifier
17	radar transmitter
18	radar receiver
19	signal processing unit
20	display

α	horizontal beam width
β	vertical beam width
γ	radiation tilt angle

e	height housing
d	distance

Claims

1. Wrist-wearable device comprising an outer housing (1) with a back cover (3), a front cover (4) being parallel to said back cover (3), and a circumferential wall (2) there between, said wall being perpendicular to the back cover (3) and to the front cover (4) and being made of an electrically conducting material, said device further comprising two slot antennas (8, 9) being able to send and to receive electromagnetic signals, each slot antenna (8, 9) comprising a case (8b, 9b) having electrically conducting inner surfaces and being fitted in the housing (1), said case (8b, 9b) being limited on one side by an outer face (8c, 9c) lying substantially in a common plane with the wall (2) of the housing (1), a slot (8a, 9a) being formed in said outer face (8c, 9c) of the case (8b, 9b), the inside of the case thereby forming a cavity of the slot antenna (8, 9) wherein an high impedance portion is provided in the circumferential wall (2) between the outer faces (8c, 9c) of the two cases (8b, 9b) and wherein one of the slots is extending substantially in a direction perpendicular to the back cover (3) and the front cover (4).

2. Device according to claim 1, **characterised in that** the high impedance portion comprises a portion made of an electrically insulating material or a geometrical structure avoiding surface coupling.

3. Device according to any of the preceding claims, **characterised in that** the case (8b, 9b) occupies substantially the complete space in a direction ranging from the back cover (3) to the front cover (4).

4. Device according to any of the preceding claims, **characterised in that** it further comprises a shield-

ing element (5) lying in the plane of the back cover (3) and protruding from the wall (2) in an area below the slot antenna (8, 9).

5. Device according to any of the preceding claims, **characterised in that** the outer housing (1) is at least partly made of a conducting material, in particular of metal.

6. Device according to any of claims 1 to. 4, **characterised in that** the back cover (3) is made of a non-conducting material, in particular of a plastic material.

7. Device according to claim 6, **characterised in that** it comprises at least one electrically conducting surface (8d, 9d) on the circumferential wall (2), said electrically conducting surface (8d, 9d) forming a continuous antenna surface together with an adjacent outer surface (8c, 9c) of the slot antenna (8, 9).

8. Device according to any of claims 1 to 7, **characterised in that** the slot (8a) of the first slot antenna (8) is tilted with respect to the slot (9a) of the second slot antenna (9).

9. Device according to any of claims 1 to 8, **characterised in that** it further comprises a transmitter (17) generating a radar signal and connected to a first slot antenna (8) and a receiver (18) connected to the second slot antenna (9), the output of the receiver being transmitted to a signal processing unit (19).

10. Device according to claim 9, **characterised in that** the signal processing unit (19) is arranged to compute a speed of and/or a distance covered by a person wearing the wrist wearable device using signals captured by the second slot antenna (9).

11. Device according to any of the preceding claims, **characterised in that** it further comprises a signal processing unit (19) arranged for computing a speed of a user wearing the device and display means (20) arranged to display said speed.

12. Device according claim 11, **characterised in that** the signal processing unit (19) is furthermore arranged for computing a distance covered by the user wearing the device, the display means (20) arranged to display said the speed and the distance covered.

Patentansprüche

1. Am Handgelenk tragbare Vorrichtung, die ein Außengehäuse (1) mit einer hinteren Abdeckung (3), einer zu der hinteren Abdeckung (3) parallelen vorderen Abdeckung (4) und einer Umfangswand (2) dazwischen umfasst, wobei die Wand zu der hinteren Abdeckung (3) und zu der vorderen Abdeckung (4) senkrecht ist und aus einem elektrisch leitenden Material hergestellt ist, wobei die Vorrichtung ferner zwei Schlitzantennen (8, 9) umfasst, die elektromagnetische Signale senden und empfangen können, wobei jede Schlitzantenne (8, 9) einen Kasten (8b, 9b) mit elektrisch leitenden inneren Oberflächen umfasst, der in das Gehäuse (1) eingepasst ist, wobei der Kasten (8b, 9b) auf einer Seite durch eine äußere Fläche (8c, 9c) begrenzt ist, die im Wesentlichen in einer gemeinsamen Ebene mit der Wand (2) des Gehäuses (1) liegt, wobei ein Schlitz (8a, 9a) in der äußeren Fläche (8c, 9c) des Kastens (8b, 9b) ausgebildet ist, wodurch der Innenraum des Kastens einen Hohlraum der Schlitzantenne (8, 9) bildet, wobei ein Abschnitt mit hoher Impedanz in der Umfangswand (2) zwischen den äußeren Flächen (8c, 9c) der beiden Gehäuse (8b, 9b) vorgesehen ist und wobei sich einer der Schlitze im Wesentlichen in einer Richtung senkrecht zu der hinteren Abdeckung (3) und der vorderen Abdeckung (4) erstreckt.

2. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Hochimpedanzabschnitt einen Abschnitt aufweist, der aus einem elektrisch isolierenden Material oder aus einer geometrischen Struktur, die eine Oberflächen-kopplung vermeidet, hergestellt ist.

3. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Kasten (8b, 9b) im Wesentlichen den gesamten Raum in einer Richtung von der hinteren Abdeckung (3) zu der vorderen Abdeckung (4) belegt.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sie ferner ein Abschirmelement (5) umfasst, das in der Ebene der hinteren Abdeckung (3) liegt und von der Wand (2) in einem Bereich unterhalb der Schlitzantenne (8, 9) vorsteht.

5. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das äußere Gehäuse (1) wenigstens teilweise aus einem leitenden Material, insbesondere aus Metall hergestellt ist.

6. Vorrichtung nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die hintere Abdekkung (3) aus einem nicht leitenden Material, ins-besondere Kunststoff hergestellt ist.

7. Vorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** sie wenigstens eine elektrisch leitende Oberfläche (8d, 9d) auf der Umfangswand (2) aufweist, wobei die elektrisch leitende Oberfläche

(8d, 9d) zusammen mit einer benachbarten äußeren Oberfläche (8c, 9c) der Schlitzantenne (8, 9) eine ununterbrochene Antennenoberfläche bildet.

8. Vorrichtung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** der Schlitz (8a) der ersten Schlitzantenne (8) in Bezug auf den Schlitz (9a) der zweiten Schlitzantenne (9) geneigt ist.

9. Vorrichtung nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** sie ferner einen Sender (17), der ein Radarsignal erzeugt und mit einer ersten Schlitzantenne (8) verbunden ist, und einen Empfänger (18), der mit der zweiten Schlitzantenne (9) verbunden ist, umfasst, wobei der Ausgang des Empfängers zu einer Signalverarbeitungseinheit (19) gesendet wird.

10. Vorrichtung nach Anspruch 9, **dadurch gekennzeichnet, dass** die Signalverarbeitungseinheit (19) dazu ausgelegt ist, unter Verwendung von Signalen, die von der zweiten Schlitzantenne (9) aufgefangen werden, eine Geschwindigkeit und/oder eine Strekke, die von einer Person, die die am Handgelenk tragbare Vorrichtung trägt, zurückgelegt wird, zu berechnen.

11. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sie ferner eine Signalverarbeitungseinheit (19), die dazu ausgelegt ist, eine Geschwindigkeit eines Anwenders, der die Vorrichtung trägt, zu berechnen, und Anzeigemittel (20), die dazu ausgelegt sind, die Geschwindigkeit anzuzeigen, umfasst.

12. Vorrichtung nach Anspruch 11, **dadurch gekennzeichnet, dass** die Signalverarbeitungseinheit (19) ferner dazu ausgelegt ist, eine Strecke zu berechnen, die vom Anwender, der die Vorrichtung trägt, zurückgelegt wird, wobei die Anzeigemittel (20) dazu ausgelegt sind, die Geschwindigkeit und die zurückgelegte Strecke anzuzeigen.

Revendications

1. Dispositif portable au poignet comprenant un boîtier externe (1) avec un fond (3), un couvercle (4) étant parallèle audit fond (3), et une paroi périphérique (2) entre les deux, ladite paroi étant perpendiculaire au fond (3) et au couvercle (4) et étant constituée d'un matériau électriquement conducteur, ledit dispositif comprenant en outre deux antennes à fente (8, 9) capable d'envoyer et de recevoir des signaux électromagnétiques, chaque antenne à fente (8 , 9) comprenant une boîte (8b, 9b) ayant des surfaces intérieures électriquement conductrices et étant montée dans le boîtier externe (1), ladite boîte (8b, 9b) étant limitée d'un côté par une face externe (8c, 9c) s'étendant sensiblement dans un plan commun avec la paroi (2) du boîtier externe (1), une fente (8a, 9a) étant formée dans ladite face externe (8c, 9c) de la boîte (8b, 9b), l'intérieur de la boîte formant ainsi une cavité de l'antenne à fente (8, 9), **caractérisé en ce qu'**une portion de haute impédance est agencée dans la paroi circonférentielle (2) entre les faces extérieures (8c, 9c) des deux boîtes (8b, 9b) et **en ce qu'**une des fentes s'étend sensiblement dans une direction perpendiculaire au fond (3) et au couvercle (4).

2. Dispositif selon la revendication 1, **caractérisé en ce que** la portion de haute impédance comprend une portion réalisée en un matériau électriquement isolant ou une structure géométrique évitant le couplage de surface.

3. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la boîte (8b, 9b) occupe sensiblement l'espace complet dans une direction allant du fond (3) au couvercle (4).

4. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre un élément de blindage (5) s'étendant dans le plan du fond (3) et faisant saillie de la paroi (2) dans une zone en dessous de l'antenne à fente (8, 9).

5. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le boîtier extérieur (1) est au moins partiellement réalisé en un matériau conducteur, en particulier en métal.

6. Dispositif selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** le fond (3) est réalisé en un matériau non conducteur, en particulier en matériau plastique.

7. Dispositif selon la revendication 6, **caractérisé en ce qu'**il comprend au moins une surface conductrice (8d, 9d) sur la paroi périphérique (2), ladite surface conductrice de l'électricité (8d, 9d) formant une surface d'antenne continue avec une surface extérieure adjacente (8c, 9c) de l'antenne à fente (8, 9).

8. Dispositif selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** la fente (8a) de la première antenne à fente (8) est inclinée par rapport à la fente de la seconde antenne à fente (9).

9. Dispositif selon l'une quelconque des revendications 1 à 8, **caractérisé en ce qu'**il comprend en outre un émetteur (17) générant un signal radar et relié à une première antenne à fente (8) et un récepteur (18) relié à la seconde antenne à fente (9), la sortie du récepteur étant transmise à une unité de traite-

ment du signal (19).

10. Dispositif selon la revendication 9, **caractérisé en ce que** l'unité de traitement du signal (19) est agencée pour calculer une vitesse et / ou une distance parcourue par une personne portant l'appareil portable au poignet en utilisant des signaux captés par la seconde antenne à fente (9).

11. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend en outre une unité de traitement du signal (19) agencée pour le calcul de la vitesse d'un utilisateur portant le dispositif, et des moyens d'affichage (20) agencés pour afficher ladite vitesse.

12. Dispositif selon la revendication 11, **caractérisé en ce que** l'unité de traitement du signal (19) est en outre agencée pour le calcul d'une distance parcourue par l'utilisateur portant le dispositif, les moyens d'affichage (20) agencés pour afficher ladite vitesse et la distance parcourue.

Fig. 1

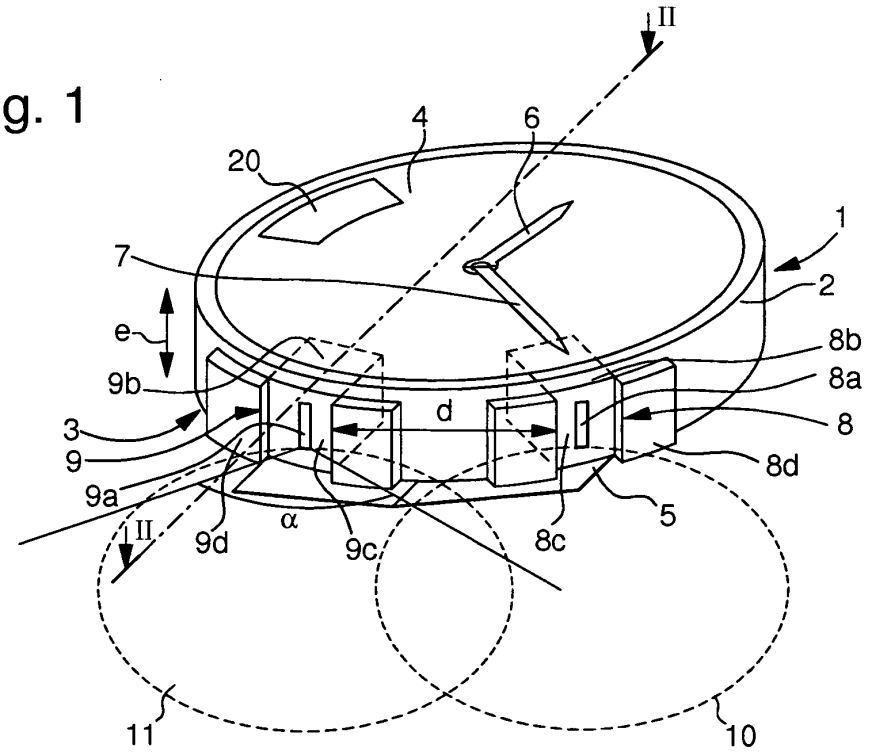


Fig. 2

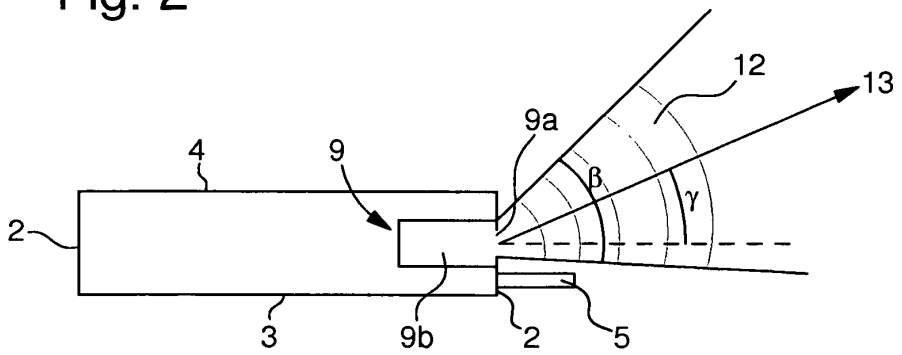
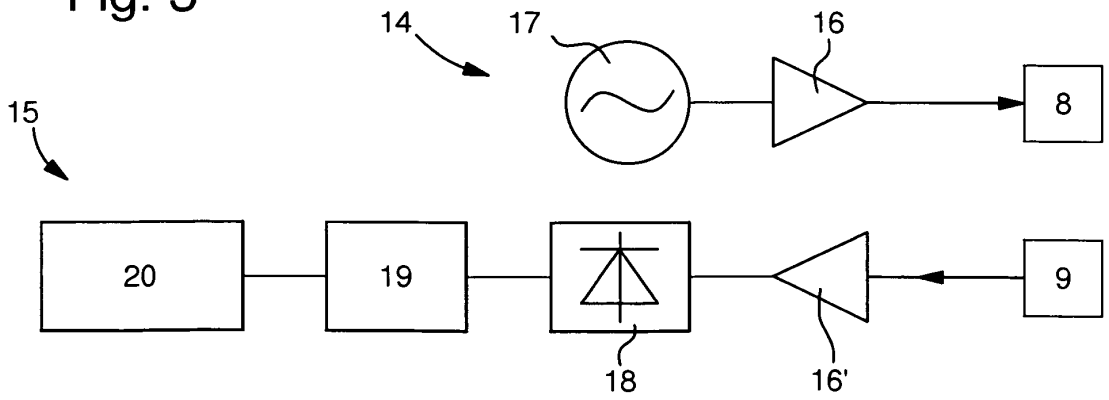


Fig. 3



REFERENCES CITED IN THE DESCRIPTION

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